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LITERATURE FOR 1913 ON THE BEHAVIOR OF THE LOWER INVERTEBRATES

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In continuing his studies on the rheotaxis of isopods Allee (1, 2) has found that when the positive rheotaxis of Asellus is strong there is a high degree of efficiency in the reactions to the current. Low efficiency is correlated with indefinite or negative responses. When molting occurs sensitiveness to currents is greatly reduced. Low oxygen content and KCN cause a reduction or reversal of the usual reactions. There is little relation between the vigor of the reaction to mechanical shocks and the sign of the rheotactic response. KCN, and lack of oxygen produce at first an increase of sensitiveness to shocks followed by a period of dulled sensitivity. Often sensitiveness is increased during the molting period. No daily rhythms of behavior were observed.

In a series of experiments on the taste and smell of the crustacean Palaemon, Balss (3) concludes that the olfactory sense is located partly in the antennae and partly in other parts of the body. Taste is located not in the antennae, but in the mouth parts and tips of the thoracic legs.

The extensive studies of Bancroft (4) on the much discussed subject of the phototaxis of Euglena have shed much light on several of the vexed questions involved. Orientation which has been considered a function of differential sensibility is found to stand in no necessary relation to the latter. Positive reactions

"may be accompanied by motor reactions to either sudden shading or sudden illumination," and "the ability to react to sudden changes in illumination by means of motor reactions is possessed by Euglenae which are not heliotropic. Conversely, there are heliotropic Euglenae that cannot be made to respond to changes in illumination." The orientation to light and the ability to react to sudden changes of light intensity being to a large extent independent variables, it is concluded that the two types of reaction depend upon different mechanisms. Orientation is not the outcome of trial and error, but "is as direct as the locomotor mechanism of the organism will allow."

Baunacke (5) gives a general discussion of the function of the statocyst in various invertebrates and describes several experiments showing the relation of the statocysts to the preservation of the normal position in various mollusks.

Bohn (6) has given a discussion of modifiability of behavior in lower organisms and its relation to certain physical and chemical processes. That he is correct in ascribing associative memory to protozoans and coelenterates may be questioned by many comparative psychologists, but all will find his treatment of the topic suggestive.

The experiments of Miss Brundin (7) on some terrestrial amphipods from California showed that the more terrestrial of the two species studied, *Orchestia pugettensis*, is the more strongly positive to light. This species commonly lives in holes in the sand above high tide mark, while *Orchestia traskiana* lives in cooler and moister conditions under sea weeds and rubbish nearer the water's edge. It was found that both dryness and heat tend to make negative Orchestias positive. Enforced activity also produces the same effect. Orchestias compelled to lie on one side by being compressed between two glass plates would nevertheless manage to go toward the light. Specimens with one eye blackened over would at first perform circus movements toward the normal side, but after a time they would go to the light in a more direct course. There is a discussion of the relation of the behavior of the two species to the choice of their respective habitats.

Brunelli (8) has given a resumé of the behavior of hermit crabs and adds a detailed description of how *Pagurus arrosor* detaches the anemone *Adamsia* and then places it, base down-

ward, on the shell which this crab inhabits. The author discusses the origin and significance of the symbiotic relations of these two forms.

Buddenrock (9) finds that in Branchiomma and certain other annelids that bore into the mud or sand, the statocyst does not serve for the perception of jars, but affords stimuli causing the side of the tail end in contact with the substratum to bend downward; *i.e.*, the statocyst is the organ of geotaxis. Extirpation of both statocysts destroys the power of boring straight into the earth.

Car (10) gives a not very illuminating discussion of ciliary movement in general and the locomotion of the ciliate infusoria; he also touches upon the movements of gregarines.

After section of the ventral cord of diplopods, Clement (11) finds that co-ordinated movements between the appendages in front of and behind the incision continue to occur. Stimuli afforded by muscular strains are probably instrumental in effecting this co-ordination. Reactions of particular appendages were studied and their influence on the movements of other appendages. Rolling into a spiral, which persists after decapitation, no longer occurs if the first three metameres are removed.

Cole (12) finds that the starfish *Asterias forbesi* locomotes most frequently with the madrepore or one of the adjacent rays in front. This "physiological anterior" of the starfish "corresponds to the anterior of the spatangoids with respect to the position of the madreporite." Starfishes tend to crawl in the same general direction in successive trials, but when changes of direction occur there is a tendency for the locomotor impulse to "shift or rotate gradually around the body in one direction or the other."

In experiments on co-ordination and righting in the starfish, Cole (13) found that individuals with the radial nerves cut near the circum-oral nerve ring were nevertheless able to right themselves. The operation was accomplished only with difficulty owing to the lack of co-ordinated activity in the different arms. Specimens with one or more arms amputated were found to right themselves as were also the individual arms.

Cowles (14) describes the method by which *Cryptodromia tuberculata* St., a sponge-carrying crab, snips loose a piece of sponge, pushes its body under it and carries it off while holding

it with the posterior pair of legs. *Alpheus pachychirus* St. has the curious habit of forming a tube of an alga which grows in the form of a sheet of threads. The Alpheus lies on its back, draws the folds of the alga together on either side, then, by pulling the threads through holes made by its feet, actually sews together the folds of the alga to form a complete tube.

By throwing light from various differently colored surfaces on the daphnid Simocephalus, Erhard (16) noted that the eye reacted in the same way as to changes in the intensity of any one color. He concludes, like Hess, that daphnids are color blind.

The behavior of the parasitic copepod *Lernaeopoda edwardsii* has been studied by Fasten (17) who finds that the free swimming young habitually move in a spiral course, thus increasing their opportunities of coming into contact with their host. The larvae are positive even in strong light and swim near the surface during the day, but sink toward the bottom at night. Observations were made on thigmotaxis, geotaxis, reactions to temperature changes, and to various chemicals, and also on the method by which the larvae attach themselves to the gills of their host, the trout.

According to Franz (18) phototaxis is either a device for scattering the species, as when it occurs in the larvae of animals inhabiting the bottom of waters, or in a movement of flight (Fluchtbewegung) by which the animal escapes unfavorable or threatening conditions. For the arguments supporting this unique standpoint reference must be made to the original paper. Franz (19) has also given a more or less popular account of the behavior of snails.

Frisch and Kupelweiser (20), from a series of experiments on Daphnia and Artemia, conclude that these animals have the power of distinguishing different colors. If Daphnias which have become indifferent to a certain intensity of light are exposed to a light of less intensity they become positive, whereas if the intensity of light is increased they become negative. However, if one interposes a blue screen, the daphnids in spite of the diminution of light intensity become negative. If one adds yellow light to the white light to which Daphnids have become indifferent there is evoked a positive reaction notwithstanding

the fact that the intensity of the light is increased. Artemia reacts in much the same way as Daphnia, and the author concludes that lights of different wave lengths produce different effects.

Frölich (21) has experimented on the isolated eyes of Octopus, noting fluctuations in the current of action under constant stimulation by light. Rhythmical fluctuations of the current were noted which varied in frequency and extent with the intensity and wave length of light.

Gee (22) has made a thorough investigation of the behavior of two species of leeches, *Dina microstoma* Moore and *Glossiphonia stagnalis* L. His paper includes a description of the general habits of the two species; their various movements; food and feeding; reactions to light, heat, currents of water, and chemicals; daily changes of behavior; the behavior of the young, and various other features of the normal activities of these animals, thus affording a foundation for the analytical work which follows. Under the head of modifiability of behavior are treated the various responses of the animal to repetitions of the same stimulus and their different determining factors, acclimatization to stimuli, fatigue, depression induced by various chemicals and its relation to fatigue, and the influence of hunger and satiety on various reactions. Of particular interest is the parallelism between the effects of fatigue and influence of those substances, sarco-lactic acid, carbon dioxide, etc., which are supposed to cause fatigue in higher forms.

Gee's paper (23) on the modifiability of behavior in the sea anemone Cribrina embodies an attempt to account for the changes of behavior in this form in terms of certain physiological processes. Food produces a copious secretion of mucus and after a certain amount of food has been taken in the animal refuses to take more. Why does the surfeited anemone reject the food ? It is not due to fatigue of the muscles involved in prehension or swallowing. If the anemones are stimulated by beef extract or oyster juice they secrete mucus copiously and soon reject solid food. Various salts were found to cause the anemone to reject food. The refusal of food is not the result of conditions of assimilation; apparently it is the effect of conditions brought about by the secretion of mucus. Cribrina

remains expanded in the light and contracted in the dark, and shows no diurnal or tidal rhythms independently of the changes of the stimuli directly affecting it.

In the course of an investigation of the alleged color sense of the lower animals Hess (24) has experimented on various fishes, the larvae of Culex, and the anemones Cerianthus and Bunodes. The general results are confirmatory of his contention that the lower animals are color blind, *i.e.*, they are affected only by the intensity and direction of the light rays.

In the course of a general account of the biology of *Asellus aquativus* Kaulbersz (26) describes many features of the behavior of this isopod, and especially its reaction to chemical, photic and tactile stimuli. Observations were also made on the reactions of Gammarus and Niphargus.

Kchschkowsky (27) has studied the effect of the constant electric current on various cestodes, nemerteans and annelids. Most forms reacted by a contraction of the longitudinal muscles when the anode was placed at the head end and the cathode near the tail.

Following a description of the histology of the sensory epithelium of *Microstoma caudatum*, Kepner and Taliaferro (28) have given an account of the reactions of the animal to various chemicals. The reactions were markedly influenced by variations in its "physiological tone." Removal of the ciliated pit of one side of the head caused circus movements toward the intact side. "The bilateral disposition of the ciliated pits serves to direct the animal in its movements." The same authors (29) have investigated the food taking of *Amoeba proteus*. They find much variability in the reactions to food, depending upon the condition of the animal and various external influences.

Lillie and Just (30) have made several interesting observations on the breeding habits of Nereis at Woods Hole, Mass. Breeding occurs at certain periods which are influenced mainly by lunar cycles, but which are also affected by several other factors, such as time of day, weather, light and possibly temperature. During the breeding time swarms of both sexes are found swimming near the surface and when the females discharge their eggs the males discharge their sperm. The exciting factor which stimulates the males to the discharge of their sperm was shown to be some substance discharged by the egg-bearing females.

Spent females had little influence on the sperm discharge of the males, but water which had contained an egg-bearing female would quickly provoke discharge of the sperm. The substance inducing the discharge of the sperm is quite labile as it is destroyed by heat or by standing a few days in sea water.

Lillie (31) has made a study of the behavior of the spermatozoa of Nereis and Arbacia. The sperm cells of Nereis are positively chemotactic to weak solutions of CO_2 and various other acids, but they show no response to alkalis. " In contact with any solid object Nereis spermatozoa tend to carry out circus movements in an anti-clockwise direction, when fresh, but soon come to rest." They are especially attracted by substances given off by the eggs. The same is true for the sperm of Arbacia, whose general behavior resembles that of the sperm of Nereis. Chemotaxis to egg substances is probably an important factor in bringing about the fertilization of the egg.

MacCurdy (32) has shown that *Asterias forbesi* is negatively phototactic. He finds that light produces chemical changes in the starfish which were studied by examining the sea water containing specimens exposed to the light.

Metalnikow (33) finds that Paramoecia which at first ingested injurious substances came after a few hours to reject them. In another communication (34) experiments are reported on feeding infusoria with sepia and carmine. At first both sepia and carmine were ingested; after a few days the carmine was ingested in very small quantities, but the sepia was engulfed in considerable quantity.

Moore (35) finds that *Diaptomus bakeri* ordinarily indifferent to daylight becomes negative upon the addition of small amounts of caffein, strychnin, and atropin, while acids, alcohol and ether evoke a positive response.

Morse (36), who has made a detailed study of the habits of Solenomya, finds that this primitive bivalve burrows with the posterior end downward, thereby forming an exception to all other known lamellibranchs. Solenomya swims actively through the water by the combined action of the foot and valves of the shell.

Like several previous investigators, Mrázek (37) finds that Branchipus is positively phototactic and ordinarily swims on its back. This orientation was preserved after the removal of the eyes.

Orton (38, 39) has given a detailed account of the feeding mechanism and mode of feeding in Crepidula with observations on the feeding activities of various other mollusks.

Eubranchipus dadayi was found by Pearse (40) to be positively phototactic and in general positively geotactic in the light and negatively so in the dark. After mating the females resist seizure by the males and usually leave the surface and keep quiet near the bottom.

By means of several experiments on the starfish Plessner (41) has brought out several differences between the functions of the ocelli and the general photodermic sensitivity of the body. The latter serves only as a means of reaction to variations in the intensity of light. The ocelli do not enable the starfish to see images nor to detect movement, but by their means the starfish is able to direct its movements toward a slit of light or a dark object. Removal of the ocelli involves destruction of the power of locomotion to special regions of light or shade.

H. Prizbram and Matula (42) have studied the functions of the branches of an abnormal antenna of the spiny lobster Palinurus. The antenna was furnished with three flagella. Two of these conveyed sensory stimuli but did not respond by movement, but the third responded by movement to the application of stimuli.

K. Przibram (43) has pointed out certain analogies between the random movements of some of the Protozoa and Brownian movements.

Sexton and Mathews (45) have described the food habits, mating and general behavior of the young in *Gammarus chevreuxi*, a species inhabiting fresh and brackish waters around Plymouth, England.

Oregonia gracilis, like many other spider crabs, was found by Stevens (46) to possess the curious habit of decking itself with various foreign growths. Contrary to the results of Minkiewicz there was no tendency on the part of the crabs to select materials that correspond to the prevailing color of the environment. Blinded crabs decorate themselves but they show no reaction to light. Crabs which had been previously exposed to white, yellow, blue, green or red light show a manifest tendency to go toward the same kind of light when they are free to move toward any one of these colors.

By stroking gently various parts of the body of a snail in much the same way as these parts are stimulated during the mating activities Szymanski (47) has succeeded in evoking reactions which closely simulate those of mating. The studies of Szymanski (48) on the relation of tropisms to rapidity of movement were made partly on insect larvae and partly on leeches and earthworms. When the animals studied were in a condition of relative inactivity they progressed with less rapidity and made many trial movements in their sinuous course. When more active they become oriented more directly and progress with greater rapidity and in a straighter path. The author discusses different interpretations of the relation of trial movements to locomotor activity.

Torrey (50) has given a discussion of the rôle of trial movements in orientation, especially in the case of Euglena, which, it is contended, contrary to the views of Jennings and Mast, orients itself by direct responses to stimuli instead of by the method of trial and error.

Yung (51) has reached the unexpected conclusion that the eyes of snails despite their considerable degree of development are not light percipient organs. Other parts of the body, however, possess a photodermic sensibility.

Zimmermann (52) describes the movements and respiratory activities of the Galatheidea with especial reference to the structural adaptations involved.

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LITERATURE FOR 1913 ON THE BEHAVIOR OF SPIDERS AND INSECTS OTHER THAN ANTS

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TROPISMS

1. *Chemotropism.*—Trogardh (104) discusses the rôle of chemotropism in economic entomology, and Weiss (118a) dissertates on the odor preferences of insects.

2. *Geotropism.*—Weiss placed some hibernating individuals of the lace bug (*Corythuca ciliata* Say) in a glass cage in a warm room. As the temperature rose, some ascended vertical sticks and others, in the open, climbed one over the other, until there was a pillar several bugs high. As a rule, when the column was six bugs high it would sway and topple. These bugs behaved the same in sunshine and in shade and flashes of bright light did not alter their behavior. Individuals of three species of lady-bug beetles (*Adalia bipunctata*, *Coccinella 9-notata*, and *Megilla fuscilabris*) were deprived of food for from one to five minutes and then placed at the base of a fifteen-foot pole. Each climbed the pole: the first species an average height of eight feet; the second an average of one foot six inches in the sun and of seven feet six inches in the shade; the third an average of one foot four inches in the sunlight and of seven feet in the shade. The investigator considers this behavior an exhibition of negative geotropism.

3. *Phototropism.*—Heinrich (56) and Reiff (89) have discussed the reactions of butterflies and moths to light, and Holmes (61) has published a short note on the orientation of flies of the genus *Bombilius* to light.

Wodsedalek (124) has demonstrated that the phototropic responses of the Dermestidae vary at different life-history periods. Immediately after hatching the larva of *Trogoderma tarsale* is negatively phototactic and, if placed near a window, will move away from the light. This negative response persists

throughout the larval period, after metamorphosis, and even for a short time after mating. Soon after ovipositing, the female becomes gradually indifferent and then positively phototactic. He has also disproved the common belief that, immediately after metamorphosis, the carpet beetle goes outside of the house to breed. He found that the carpet beetles popularly known as " buffalo moths " (*Anthrenus scrophulariae*) and the black carpet beetles (*Attagenus piceus*) respond to light in the same manner as *Trogoderma tarsale*.

By means of field observations (117), Weiss discovered that different species of mosquitoes are quite unlike in their behavior towards light. Some are equally positively and negatively phototropic, some are unequally positively and negatively phototropic and others are constantly one thing or the other. Up to a certain low intensity of light, *Culex pipiens*, *C. aurifer*, *C. canadensis*, *C. sylvetris*, *C. sallinarius*, *Anpheles maculipennis* and *Wyeomyia smithii* are positively phototropic; beyond that they are negatively so, and normally appear only at night. Near the close of the season, impregnated females of *C. pipiens* become strongly negatively phototropic and seek dark hibernating quarters. *A. crucians* is positively phototropic up to noon-day intensity of light. *A. punctipennis* responds both negatively and positively, but more often negatively. *C. perturbans* is negative in its reactions. At one place, Weiss asserts that *C. sollicitans* appears to be equally negatively and positively phototropic and that the reaction is evidently dependent upon nutrition. This does not harmonize with his statement that *C. sollicitans*, *C. cantator* and *C. taeniorhynchus*, all salt-marsh forms, are positively phototropic; but that *C. salinarius*, also a salt-marsh form, is negatively phototropic.

Holmes and McGraw (60) have devised an excellent method of studying the light responses of insects. A cylindrical jar, the bottom and side of which are covered with white paper, is covered with a cone of the same material, the apex of which conceals an electric light. A small peep hole permits the investigator to view the interior of the vessel. A circular dish containing the subject of the experiment is placed on the center of the floor of the jar. No matter which way the insect turns, the illumination is of the same intensity. Insects with one eye rendered opaque were placed in the jar and stimulated to action.

All insects did not respond in the same manner. Several beetles, of three different species, showed a tendency to turn toward the blackened eye. A Jerusalem cricket, which is negatively phototactic, when crossing from one side to the other, always turned toward the left. In a series of trials, two species of the *Tachina* fly and a specimen of the fly *Eristalis tenax* made circus movements towards the normal eye.

These same two investigators constructed a light-running turntable of cardboard. An insect was held so that its feet rested on this table and its head faced either the periphery or the center. A light was placed near one side of the turntable. Any movement on the part of the insect to escape from or to approach the light would cause the table to revolve in the opposite direction. Four species of butterflies (*Pieris raphae, Melitea chalcedon*, *Eurymus eyrtheme*, and *Caenonymphia california*) and two species of flies caused the disc to rotate away from the light. In the light of these two types of experiments, Holmes concludes: "It is not possible ,we believe, to construe phototaxis entirely in terms of differential sensibility. Responses to the shock of transition, whether in the direction of an increase or a decrease of stimulus, may play a part in the orientation of many forms, but the continuous stimulating influence of light appears to be, in several cases at least, the factor of major importance."

4. *Rheotropism.*—Based upon a study of *Asellus communis*, Allee (2.) has reached the following conclusions concerning the responses of Isopods to currents of water: (1) In daily variations to currents the efficiency of the movements varies with the per cent of positive reactions. (2) Large variations in positive reactions are usually accompanied by similar variations in efficiency. (3) Low efficiency is accompanied by a low per cent of positive and a high per cent of indifferent responses. (4) High efficiency is always accompanied by a low per cent of indifferent responses, and usually by a low per cent of negative and a high per cent of positive responses. (5) In exceptional cases, high efficiency may be accompanied by either a low or high per cent of positive reactions. In another communication (1) the same author states that during moulting all currents are disregarded by these animals. This effect persists for about five hours after the complete casting of the skin.

5. *Thigmotropism.*—According to Weiss (118), commencing

about the middle of September, the mosquito *Culex pipiens* becomes positively thigmotactic and seeks dark quarters. After becoming acclimated to its surroundings, its normal negative phototropism is entirely replaced by positive thigmotropism. At the approach of spring the mosquito becomes positively phototropic up to a certain point.

VISUAL SENSATIONS

Hunter (63) thinks that form discrimination by animals is always pattern discrimination.

Seitz (91) discusses the vision of insects.

Karl v. Frisch's (42) recent contribution is one of the best studies extant on the color vision of insects. He arranged thirty graded discs of cardboard, extending from white to black, upon a rectangular piece of cardboard in such a manner that it was possible to insert other discs of the same size among them. So far as shades of grey were concerned, the discs were arranged on the rectangle in an irregular manner. Two yellow discs, each supporting a watchglass of honey, were placed among the grey discs. After the bees had been collecting food from these yellow discs for two days, they were removed and new yellow discs, each supporting an empty watchglass, were placed on a different part of the rectangle. Immediately these were visited by the bees; but no attention was paid to the grey discs. Bees that had been trained to forage from yellow, alighted on the yellow pencil with which Frisch was taking notes. In a similar manner bees were trained to forage from blue discs. Such bees, in four minutes, made 282 visits to the blue discs and only three to the grey. Empty watchglasses were now placed on the blue discs and similar glasses, containing sweetened water, on the grey. The bees attempted to feed from the empty dishes on the blue discs, but paid no attention to the full ones on the grey. In like manner an attempt was made to train bees to collect from red discs. Such bees visited equally the red, dark grey and black papers. Evidently bees have color vision, for they can distinguish yellow and blue from greys; but they are color blind to red.

On reading of these researches, Mrs. Ladd-Franklin (67) wrote to Frisch and asked him to make some tests to see if there was not a certain blue-green, as well as red, to which bees

were color blind. He replied that he had made such tests and that bees were color blind to that portion of the spectrum. In other words, bees have a dichromatic vision, and their colors are blue and yellow. Thus their vision resembles that of the protanopic form of red-green color blindness. To Mrs. Franklin the results of these researches are gratifying, for they seem to support her theory of color vision and to militate against Hering's.

EMOTIONS

In experimenting with the common roach on a maze, Turner (105) noticed certain jumping activities which seemed to indicate an exhibition of will. He writes: "Although the jumping activity results in a plunge into the water, it resembles neither the dashes into the water made by a roach on being placed on the maze for the first time nor the falls into the water by roaches trying to run the maze. The roach pauses at the edge of the maze and explores outward and downward with its antennae. It acts as though it were trying to see something at a distance and then, after a pause, makes what an athlete would call a broad jump. Many roaches displayed this jumping behavior, but some were more prone to jump than others. * * * This jumping attitude is so characteristic that one can always tell when a roach is likely to jump. I say likely to jump instead of going to jump, because, after a roach has once jumped into the water, the jumping attitude does not always result in a spring. To see a roach, which has learned to avoid rushing off of the maze into the water and which will struggle hard to keep from slipping from the edge of a runway into the water, halt, reach outward and downward with its antennae, act as though it were trying to see what is beyond, pause and then jump is food for much thought. Have we not here a conflict of impulses and is not the jumping or refusing to jump the resultant of this conflict? Is not such a resultant what the human psychologists call an act of will?"

See Benard under Maternal instincts.

MATING INSTINCTS

Newell (78) describes the mating of the rice weevil, Smith (95) of a stone fly, Morgan (76) of mayflies, Gerhardt (47) of some crickets and locusts and Walker (111) of *Argia moesta*.

Fabre* states that the praying mantis of Europe is polyandrous and that the female eats her spouse. Phil and Nellie Rau (86) write that our American praying mantis (*Stegomantis carolina*) is both polyandrous and polygamous.

Fabre (39) describes the mating of several spiders. That of the angular epeira, a large garden spider, is peculiar. At nine o'clock on an August evening, the female was resting on the foundation line of her web. Cautiously a small male approached and receded several times. After a short period of this behavior, the two lovers were face to face. The female was calm and motionless; the male bristling with excitement. Timidly he touched her with a leg and then suddenly dropped from the support, spinning his drag-line as he fell. Returning, he teased her with legs and palpi. Gripping the thread with her tarsi, the female turned several somersaults and then presented the under side of her paunch to the dwarf and allowed him to fondle it with his palpi. Mating once accomplished, the male darted away, never to return.

NEST-BUILDING AND MATERNAL INSTINCTS

Coad (26) describes the oviposition of the mosquito *Culex abominator* and Fabre (39) relates many interesting things about the maternal instincts of spiders.

Buttrick (20) reports that the eggs of the salt-marsh mosquito *C. sollicitans* Walk. are deposited singly upon the mud of a salt marsh, where they remain dormant until covered by the tide or the rain. Then they hatch in a few hours and become adults in from six to fifteen days.

Parrott (81) describes the oviposition of three species of tree crickets: *Oecanthus niveus* DeGeer deposits its eggs singly at the sides of dormant buds, in the fleshy region, at the axils of the leaves of the apple, elm, plum, cherry, peach, walnut, wild crab, hawthorn, witchhazel, chestnut, red oak, maple, butternut, lilac and raspberry; *O. nigricornis* lays its eggs, in rows, upon the raspberry, blackberry, horseweed, goldenrod, willow, elder, maple, elm, sumac, grape, peach and probably others; *O. quadripunctatus* oviposits in weeds, principally the wild carrot, goldenrod and aster. The eggs are arranged in rows.

Phil and Nellie Rau (86) announce that it requires two hours

* Social Life in the Insect World. The Century Co., 1912, pp. 79-85.

for the mantis to construct its egg-case. When ready to oviposit, the mantis arranges herself, head downward, upon a twig. The last two abdominal segments expand and contract, otherwise the body is quiet. A ribbon of whitish substance, resembling tooth-paste, issues from the tip of the abdomen and is pressed against the twig. This ribbon soon becomes frothy. By means of the ovipositor this mass is moulded into the egg-case. (Full details are given in the paper.) While the case is being fashioned, an egg is laid in each cell. Immediately after laying, the mantis walks off a short distance, flexes her body and consumes what is left of the nest-forming material.

Hartman (55) states that the potter bee (*Eumenes belfragei* Cress.) moistens the clod with fluid from her mouth, before cutting out a piece with which to help construct on a culm of Bermuda grass her waterbottle-shaped nest. All of the work of plastering, modeling and smoothing is performed by the mandibles and the first pair of legs.

Strung along a road for about an eighth of a mile, Nichols (79) discovered numerous nests of the mining bee *Empor fuscojubatus* Ckll. and watched the bees at work. The nest is begun as a semicircular depression. The soil is moistened with water brought in the mouth from a pond 75 yards away, is loosened by the mandibles and is cast aside by the second and third pairs of legs. As the burrow increases in depth, a portion of the removed soil is used to form a rim of moistened earth around its mouth. When the nest has been stored with pollen and the egg laid, this rim is removed and used to partly fill the burrow. This partial filling of the nest leaves a shallow depression to mark the spot. Less than 24 hours are required to complete the nest.

Bénard (8) observed a large burrowing beetle (*S. sacer* L.) rolling a ball the size of a small apple. He constructed a pen out of pieces of tile and placed the beetle and her burden therein. Immediately she seemed to lose interest in her ball. The beetle was then placed on the outside of the enclosure; but her ball of manure was left on the inside. The beetle darted off as though it were trying to escape. After making several unsteady strides, she halted and, for a moment, remained inactive. Then she returned to the tile fence that enclosed her treasure. After making several ineffective attempts to climb the wall, she tun-

neled beneath the tile and thus reentered into the presence of her ball. There she rested, calmly waving and cleaning her antennae. He repeated the experiment with two individuals of another species of burrowing beetles (*S. atteles*); but each scampered off as soon as she was placed on the outside of the enclosure. This is an interesting display of maternal instinct. Bénard thinks that the beetle reflected. Undoubtedly we have hesitation followed by action; but, may we not interpret it in the following manner? A stimulus from her ball, plus certain internal factors, was impelling the beetle to draw near to the ball; the grasp of the hand produced a stimulus, which, coupled with certain internal conditions, tended to induce the insect to flee. As the beetle moved farther and farther from the enclosure the effect produced by the grasp of the hand became gradually weaker and weaker until it was too feeble to affect conduct. The effect of the stimulus from the ball still persisting forced the creature to return to the enclosure. Burrowing is one of the normal instinctive activities of the burrowing beetle, hence, when unable to scale the wall, it naturally would resort to digging.

Four years ago, Roubaud,* in a single genus (*Synagris*) of potter wasps, discovered one species which stocked its burrows with enough caterpillars to last its larvae until they were ready to form pupae; another which placed a few caterpillars in each burrow and then brought more as the young needed them, and yet a third species which stored no food in its nest, but collected it and fed it to its hungry babes. Recently Wheeler (120) has discovered a mining wasp (*Aphilanthus frigidus*) which, in its maternal behavior, is intermediate between a form like *Bembex*, which captures as needed the food with which to feed her hungry larvae and those forms which stock their burrows with provisions, lay their eggs, and then pay no further attention to them. He found these wasps at Blue Hills, near Boston. Each colony covered several square yards and contained from 30 to 60 nests. The burrow, which is about one-fourth of an inch in diameter, descends obliquely and abruptly for from six to eight inches and terminates in a pocket. Similar pockets are attached to the side of the common hallway. When the ants of the genus *Formica* are having their nuptial flight, these wasps capture

* *Ann. R. Smith. Inst.* for 1910, pp. 507-526.

large numbers of the winged females. After paralyzing them and removing the wings, the wasp stores those plump ants in some of the pockets of her burrow. Later she lays an egg in one of the empty compartments. When her child has emerged, the mother brings ants from the store rooms, cuts them in two, and feeds them to the greedy larva. When this charge has developed into a pupa, she lays another egg and raises another larva in the same manner.

FOOD PROCURING AND DEFENSIVE INSTINCTS

Newell (78) has described the feeding habits of the rice weevil, Ely (37) of *Cleonus calandroides*, Webster (114) of *Gypona octolineata* and Gillette (48) of some *Pemphiginae*.

Bishopp and King (12) assert that, with rare exceptions, the adult is the only form of the Rocky Mountain spotted fever tick that attacks man.

Linstow (68) mentions the animal diet of some caterpillars.

According to Lucy Wright Smith (95), the stone fly (*Perla immarginata*) is both carnivorous and cannibalistic; the presence of diatoms in its stomach is the only evidence of an herbivorous diet.

After stating that 1380 larvae of the Mediterranean fruit fly were obtained from 25 tropical almonds, H. H. P. Severin (92) gives a list of 38 fruits that serve as food-hosts of the larvae of this species of fruit fly.

Phil and Nellie Rau (86) give a list of the insects consumed by the mantis studied by them. These mantids are strictly carnivorous, even cannibalistic; but they will not eat robber-flies, nor stink-bugs; nor would they touch the potato beetle, except when very hungry.

These same investigators (87) have demonstrated that larval wasps often have the capacity for more food than is stored in their cells by the mother wasp. They induced one larva of *Trypoxylon albitarse* to consume two and a half and another to eat two and a fourth more spiders than had been stored in their cells.

In addition to other material, Anna Morgan (76) gives, in tabulated form, the foods of the nymphs of several species of mayflies.

According to Doane (34) the rhinoceros beetle attacks the

succulent crown of the cocoanut tree. With its horn, the beetle cuts a gash in the tree and gets access to the juice, which is its only food. The succulent crown is the vital part of the tree and one or two beetles will kill a tree in a year.

A fly robbing a spider is about the last thing one would imagine, yet Frost (46) noticed three flies of the species *Desmometopa latipes* Meigen dart under the legs of a spider (*Phidippus multiformis* Emerton) and suck the juices of a bug upon which the arachnid was feeding.

It has long been known that certain tropical spiders prey upon small birds. Now Chubb (24) informs us that there is a large spider (*Thalassius spenceri* Chubb) which catches small fish and tadpoles. When this spider goes afishing, it rests its hind pair of legs upon a stone and the tips of the other six outstretched legs upon the water. With its head at about the center of the cordon of legs, the spider awaits developments. The moment a small fish or tadpole appears within range, the legs close about it, like the claws of a trap, and the mandibles deliver a deadly blow. The captive is then dragged to the top of the rock and eaten. Rev. N. Abraham saw this spider catching fish at Greytown and Rev. Pascalis Bonebery observed it catching tadpoles at Marianhill.

Wheeler (121) describes the mode of defense of the stingless bee *Trigona flaveola mediorufa* Ckll. When disturbed these bees attack *en masse*, squirting upon the offender a scalding liquid which has the odor of rancid butter. This fluid is so corrosive that the spots where it touches the skin remain sensitive for several days. Other observers to the contrary, Wheeler insists that this fluid is secreted by an anal gland or glands.

Fabre (39) describes the food-procuring habits and devices of several species of spiders. His opinion as to how young spiders secure their food is certainly peculiar. It is well known that the eggs of many spiders hatch in the fall and that the young remain in the cocoon until spring. Others emerge from the cocoon and climb upon the back of their mother and remain there for several weeks. According to Fabre's opinion these spiderlings neither increase in weight nor diminish in numbers until after they have taken their "balloon flight" in the spring. Whence comes their food? If they do not increase in size there is no urgent need for tissue-building food; but, since they are

more or less active, there is need of energy-producing material. Fabre contends that they absorb this energy directly from the sun. He bases this conclusion largely upon the fact that certain spiders take special pains to expose the cocoon, and even the uncovered young, to the rays of the sun. Although this statement appeared, in the French, several years ago, it has not been generally accepted by students of spiders. There is a leaning towards the view that the young spiders are cannibalistic. Comstock* writes: "According to the observations of Dr. B. G. Wilder some of the young of *Miranda aurantia* feed upon their weaker brothers and sisters, so that from the egg-sac that in early winter contains a large number of spiderlings there emerge in the spring a much smaller number of partly grown spiders. How general this habit of cannibalism is has not been determined. McCook states that the young of the orb-weavers prey upon each other after they leave the egg sac." If Fabre is right, this is certainly a unique form of behavior.

HIBERNATION

Biddle (9) discusses the hibernation of a butterfly (*Pyrameis atalanta*), and Pictet (83) of a moth (*Lasiocampa quercus*).

According to Ewing (38) in Oregon the lady-bug beetles (*Coccinellidae*) hibernate in pockets under stones, beneath leaves and under trash. There is a partial segregation of species.

Heretofore it has been believed that the Rocky Mountain spotted fever tick hibernates only in the nymphal and adult stages. Bishopp and King (12) inform us that this is an erroneous idea. Some hibernate in the adult stage, a few in the engorged nymphal instar, but the majority hibernate in the larval stage.

Skinner (93) observes that in winter no flies occur in the rooms of the Academy of Science of Philadelphia. With the first appearance of spring both males and females appear on the windows. All of these are fresh specimens; the ptilium not being completely retracted indicates that they have recently emerged. He concludes that flies pass the winter in the pupal stage and in no other manner.

See Weiss (117, 118) under phototropism and thigmotropism.

* The Spider Book. Doubleday, Page and Co., 1912, pp. 182-183.

MIGRATION

Harte (54) describes the flight of the cotton moth in 1911, and Unsicker (108) the migration of the buck moth (*Hemiluca maia*).

According to Cockerell (27), at Boulder, Colorado, July 1st, a bug (*Lygaeus facetus* Say) appeared in incalculable numbers. In some parts of the town they were so thick that they were swept up with brooms. He thinks the migration was due to the drying up of their food plants.

Ewing (38) relates that in Oregon the lady-bug beetle (*Hippodamia convergens* Guerin) spends the spring and the summer in the lower altitudes and the fall and the winter in the higher. Although there is no fixed migration, when the aphids are few large numbers of these beetles move in certain directions in search of pollen. By the middle of August all have quit the hot, dry, valleys and moved upwards.

LOCOMOTION

Claude (25) discusses jumping spiders, Hodge (59) how far flies may travel over water, and Girault (50) the swimming of certain Tettigids.

Girault (49) amputated the antennae of several different species of moths by snipping them about an eight of an inch from the head. The flight of such individuals was irregular and tended to become circular.

Fabre (39) performed some experiments demonstrating the details of the manner in which young spiders take their "balloon flights."

See Zetek (126) under technique.

ECOLOGY

Bailey (4) discusses the faunal zones of Mexico and Walker (112) those of Canada.

Vestal (110) has made an intensive ecological study of the species of grasshoppers of a limited area.

Brues (18) has been studying the distribution of the stable fly, which is the carrier of anthrax, infantile paralysis, etc. Next to the house fly, this is the most widely distributed of all insects. It occurs in every zoological region and practically throughout most of them. It is more abundant in temperate than in tropical regions.

DISEASE SPREADING ACTIVITIES

Today the search for insect spreaders of disease has proven such a fruitful field that many are attracted thereto and each year sees a number of papers published on the subject. This year such papers have been published by E. E. Austen (3), Bishopp and King (12), Bloclock and Warrington (13), Brues (18), Hadwen (53), Jennings and King (64a), Knab (66), Mitzmain (73, 74, 74a, 75), Niewenglowski (80), Sawyer and Herms (90), Townsend (100-103) and Winslow (123). Most of these papers treat of flies and mosquitoes. To the physician these papers are of great value; to the student of behavior they are slightly interesting; to the casual reader uninteresting, for they have long learned to look upon flies and mosquitoes with dread and they are not concerned about the special work of each species. However, a paper by Wheeler (121) should interest all, for he points to an unexpected source of danger. He describes a few of the habits of certain stingless bees of Central America. Buckets containing oil for destroying mosquitoes were common. One species of bee (*Trigona pallida* Lat) was seen collecting oil from the rims of these buckets and using it in making the cerumen out of which it constructed its honey-pots. Another species (*T. ruficrus corvina* Ckll.) was noticed collecting the malodorous liquid from the insides of the garbage barrels of the crematory. A third species (*T. bipunctata wheeleri* Ckll.) used human excrement in manufacturing its cerumen. Evidently, in eating the honey collected by these wild bees, one runs a great risk of contracting typhoid fever and other diseases.

MISCELLANEOUS INSTINCTS

In addition to articles mentioned elsewhere, papers on the behavior of the arachnids have been published by Popovivi (84) and Weimar (115); on the habits of the diptera by Burrell (19), Fiske (41), Guyenot (52) and Mitzmain (73); on the habits of Collembola by Collinge (29); on the behavior of the Hemiptera by Herrick (58) and Williams (122); on the habits of the Hymenoptera by Brauns (14) and Cros (31); on the habits of the Lepidoptera by Bird (10), Champion (22), Chapman (23), Frohawk (44), Strand (98) and Stauder (96); on the habits of the Orthoptera by Meijere (72).

Comstock (30) discusses the formation and uses of the silk of spiders.

Stauder (97) asserts that the caterpillars of the cabbage butterfly (*Pieris raphae*) survives the winter in the southern part of its territory.

Bénard (6) noticed a line of beetles (*Akis bacarozzo* Schrk.) approach the dead embers of a former fire. Each selected an ember of its own shape and color and, after folding its legs and antennae against its body, clung closely to the bit of wood.

Roentgen rays.—Morgan and Runner (77) aver that neither the "hard" nor the "soft" Roentgen rays have any effect upon the cigarette beetle in any stage of its existence.

Acrobatic stunts.—This year three investigators, Bénard, Turner and Wells, have described acrobatic stunts by insects. Bénard (7) noticed a number of male beetles (*Pachypus canidae* Rt.) suspended by their hind legs from blades of grass. In Hocking Co., Ohio, Wells (119) noticed flies of two different genera (*Microcerata* and *Bremia*) hanging, suspended by their hind legs, from a spider's web. Occasionally a fly would leave the web, fly about and then return and resume the suspended attitude. Turner (105) describes broad jumping by the common roach.

Speech.—Green (51) describes the humming of some midges (*Chironimidae*) and Regan (88) discusses the stridulation of a cricket (*Gryllus campestris*).

Homing.—In studying the habits of mining bees, Nichols (79) found that some bees flew directly to the nest and that others had much trouble in finding it; some were disturbed by the presence of the investigator and others were not.

By altering the environment in the immediate vicinity of the nest of certain wasps (*Sceliphron caementarius*), Phil and Nellie Rau (87) were able to "confuse" the home-coming wasps.

Letisimulation.—Weiss (118b) describes the death feigning of the rice weevil (*Calandra oryzae*); Girault (49) finds that the skin beetle (*Trox*) letisimulates as soon as touched and that it remains rigid and still; and Newell (78) states that the rice weevil (*Lissorhoptus simplex* Say) frequently letisimulates.

MEMORY AND ASSOCIATION

Hartman (55) noticed that a certain potter wasp required twenty loads of mud to construct its nest. Each time it returned to the same clod for its load.

Turner (105) tested the ability of the common roach to learn a maze similar to those used so much by students of vertebrate behavior. The maze used was open, *i.e.*, there were no walls surrounding the runways. The maze contained several blind alleys, some of which were complex. When in use, the maze was supported by means of slender glass pillars above a wide pan of water, so that if the roach fell off of the runways it was sure to fall into water. The roach to be tested was always placed on the same portion of the maze, and before each trial the runways were washed with alcohol, to remove any odor that may have been left there by a roach. When a roach was placed on the maze for the first time, it always made many mistakes, such as rushing into or falling into the water, going into blind alleys and retracing its steps when on the right pathway. Gradually these errors were eliminated and the roach took the shortest path from the place where she was placed on the maze to its cage, which was reached by a paper inclined plane. The investigator draws the following conclusions: (1) By arranging the trials at intervals of half an hour, a roach may be taught, within a day, to run the maze. (2) The gradual manner in which errors are eliminated would cause one to conclude that the roach learns to run the maze by the trial and error method; yet, in so doing, it utilizes sense stimuli. This is evidenced by the careful manner in which it examines (often over and over again) the corners and the edges of the maze and the space adjacent thereto. (3) At times the roach acts as though experiencing the emotion the psychologists call will. (4) Although the effects of training persist for a long time, yet the memory of the roach is poor; for, after an interval of twelve hours, marked lapses are noticed. (5) In its toilet activities the behavior of the roach resembles very much the toilet-making activities of the cat. (6) In their behavior on the maze roaches display marked individuality.

TECHNIQUE

Hentschell (57) discusses insect aquaria, and Zetek (126) describes, in detail, how to raise mosquitoes in aquaria.

Hunter (62) describes and illustrates an apparatus which will maintain constant or variable temperatures from 60° F. to -10° F.

In his experiments on the flight of mosquitoes, Zetek (126)

devised a method which may prove of value to students of other groups of insects. The mosquitoes were sprayed with anilin dye and then set free. Later insects were captured, both by hand and by the aid of traps. These were placed on a piece of glass that rested on a white blotter. Each mosquito was moistened with a solution composed of three parts of glycerine, three parts of alcohol and one part of chloroform. If the sprayed individual was one of the marked specimens the dye would diffuse out.

See Holmes and McGraw (60) under phototropism.

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LITERATURE FOR 1913 ON THE BEHAVIOR OF VERTEBRATES

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VISION

Mammals. The work on vision, for 1913, although not so extended as it has been in some previous years, is interesting. The Watsons (57) report some experiments with rodents in which they used the spectral light apparatus described in the Yerkes-Watson monograph. They wished to discover whether the differential response, in the use of color, was made on the basis of wave length. Two animals were trained to react positively to red when red and green were presented simultaneously; but, in later testing, it was found that, when the intensity was varied or only one color was presented, the animals were neglecting red and reacting to green alone. "One might increase the green light enormously or eliminate the red altogether without changing the accuracy of the responses. When, however, the intensity of the green approaches the threshhold—a disturbance immediately manifests itself." Two white rats, the one trained for yellow and the other for blue, and a black-white rat and a gray Belgian hare, trained for blue, failed to perfect a discrimination in over 500 trials when both stimuli were present at full intensity. There was a rapid rise of the habit, however, when only one, positive, stimulus was given. The second stimulus was then introduced in gradually increasing intensities. In the cases where the blue was the positive stimulus the association was maintained up to nearly equal intensities. The rat trained for yellow was disturbed by blue when its energy was only one-eighteenth that of the yellow. They conclude that the long wave lengths offer very slight, if any, visual stimulation to rodents and that the response was probably made to differences of intensity.

The difficulties of such work and the dangers of premature

conclusions are illustrated in the critique of Cole's experiments with raccoons made by Gregg and McPheeters (22). These men repeated Cole's work in which the animals were taught to discriminate between two temporal series of stimuli. As will be remembered colored cards were used. They were raised above a screen by a series of levers. The animals were taught to react positively to W.B.R. and negatively to R.R.R. Cole concluded that the discrimination was made by means of vision, that it was presumably based upon brightness and that all three presentations of the series were effectual. He thought that the "carrying over" of the stimulating effects of the first two cards till the final response must be the result of an imaginal process. Only two raccoons were used in the Chicago experiments. One of these learned to respond in a fashion similar to Cole's animals. A control series of experiments included: the exchange of R.W. cards, change of operators, use of fresh color cards, washing levers, change of lever order, substitution of entirely different colors, use of bare levers without cards, and use of glass screen before levers. The conclusion was reached that the discrimination was based primarily upon an apprehension of the relative spatial position of the levers which was mediated through nose contact in active, not passive, touch. The discrimination seemed to be based exclusively upon the difference between the first members of the groups which resulted in the setting up of certain motor attitudes. The third member was common to the two groups and hence could not serve as a basis for discrimination but it did serve to release the discriminative response which had been set up by the previous stimuli. The functional relation of the second member of the series was not worked out. The authors do not deny that raccoons have and may use visual images but say that Cole's experiments do not prove their existence as the "carrying over" may be by means of motor attitudes.

In Johnson's (29) work with dogs, some of the puppies were made temporarily blind by having their eyelids sewed together before they had gained their sight. In the latter part of his monograph he attempts to give an account of the learning time and the learning methods of these blind dogs as compared with normal dogs. The problem was the opening of cage doors, having different kinds of latches, under the stimulus of hunger.

The latches were the spoon dip, turn button, lift bar, slide bar, peg-in-hole and bobbin and string. Some of the doors swung inward and some outward. His program included (1) the learning of three boxes by each dog while still blind, (2) after learning, a test for any disturbance following the darkening of the room; (3) a test of rotation of the box; (4) a retention test after 60 days; (5) the learning of three other problem boxes after the eyes had been opened. As a matter of fact there was so little difference between the results of the blind and the normal dogs that the fifth part of the program was not undertaken. The test in the darkness showed a slight disturbance in the blind animals, indicating that the light evidently had some stimulating effect. The disturbance was much greater in the normal dog. The blind and normal dogs were equally affected by the change in orientation. The retention tests for the two groups gave similar results. To the reviewer it seems unfortunate that the last part of the plan was abandoned. The mere fact that blind and normal animals give the same results in time and accuracy in a problem does not prove that the mode of procedure or the sensory control is the same. It is not asserted to be so in this case. But quite startling results often follow from the addition of a stimulus as well as from its elimination and it is to be regretted that when trained and operated animals were at hand this step was not taken.

Amphibians. The responses of young toads to intense and moderately intense artificial light, to strong and weak diffuse daylight, to sunlight and to colored light were studied by Riley (47) in a long, careful series of experiments. He sums up his work as follows: "The young toads respond negatively to the light from a projection lantern with an approximate illumination of 10,000 ca.m. within the field of the experimentation." They respond positively to incandescent light with an illumination of approximately 44 ca.m., to strong and weak diffuse daylight and to sunlight. "Except in the diffuse daylight the animals jump toward the source of the illumination in a comparatively straight line." "It is not improbable that both light intensity and ray direction in the field are factors in these photic responses. During orientation light intensity may play the more important rôle, while the rays in the field may act as a guiding factor after

orientation is complete though this does not necessarily do away with the effect of intensity."

Hess had previously shown that amphibian vision is like human, *i.e.*, under dark adaptation the long wave end is shortened and the region of greatest brightness is pushed toward the shorter wave end. Himstedt and Nagel had confirmed this conclusion by a study of the action currents of the eye. Now Babák (2), by means of the breathing method described in this journal, 1913, Nov.-Dec., shows the same thing but adds additional curious facts. By this method the stimulating effect of V seemed extraordinarily great. Even in weak intensities it was stronger than the G. He says that the filter apparatus was, of course, not absolute, yet undeniably R and V equal in brightness had different stimulus values. R had a very weak, V a very strong influence on the breathing activity. W light had a slighter stimulus value than V. It seemed to be the resultant of the RG and V effects. He thinks that this result is probably caused by the ultra-violet rays while the long thermal rays have a practically negligible effect.

Fishes. The facts as to the color vision of fish are still controverted points in which C. Hess (26, 27) and von Frisch (17, 18, 19, 20, 21) are the principal opponents. A considerable number of papers have appeared which will be discussed together since nothing is gained by separate reviews and since in each new article the whole argument is repeated with additional matter. To von Frisch the chromatic adaptation of fishes to the color of the background against which they lie is an evidence of color vision. He discusses this adaptation at length and shows how it is due to the expansion and contraction of the pigment cells. This reaction, he believes, depends upon the nervous system and he finds a center in the brain anterior to the cord whose stimulation will cause such changes. The study is continued by means of nerve section, histological methods, etc. The reaction to yellow ground was only found in those fishes which could see. *Phoxinus laevis L.* reacted to yellow ground by an expansion of R and Y pigment cells but to G, Blue, or V ground in the same way as to gray. This reaction was, therefore, due to brightness. He used blind *Crenilabrus roissali*, five groups of five fish each, and had them four weeks under experimentation.

Fish were kept for long periods in aquaria with double walls, the spaces between being filled with Nagle's color solution, and the same results were obtained. The blind fish were not affected by the red or yellow background hence pigment growth is not due to the effect of colored light. This work was demonstrated before five people. Von Frisch thinks that the adaptation to brightness does not depend upon light intensity alone but also upon color contrast and is a higher reaction than that to color as is proved by its quickness and its accuracy. He believes, too, that the expansion of the red pigment cells is also, within wide limits, independent of the brightness values of the bottom and depends alone on its color value.

The *Hochzeitkleid* is adduced as a strong bit of evidence of the color vision of fish. Why, it is asked, should they take on these brilliant colors at spawning time if these colors are of no value in sexual selection.

Von Frisch as well as Hess made experiments with colored food. When his fish which had been trained for yellow food were offered a series of gray papers together with yellow upon a gray background, they always snapped at the yellow, he says, and never at the gray. They chose red papers and not black upon a gray ground. In this respect they differ from bees. They frequently snapped at purple and yellow-green. He gives the numbers of his papers and had the results demonstrated before five people. He also fed his fish from a series of colored tubes so arranged that food could be placed in the top and the tubes sunk in the water. *Phoxinus laevis* could distinguish red-yellow, green and blue from gray one and one-half centimeters below the surface. The red and the yellow were confused. He explains this by saying that the red pigment is essentially a sex color but that later it functions in the same way as yellow. The protective colors are on the back, the sex colors on the abdomen.

Hess admits, as all must, the chromatic adaptation in fishes but criticises its significance as a proof of color vision. He also disputes some of von Frisch's facts and questions certain methods which he uses. Some apparatus was constructed by Hess by means of which two bowls containing fish could be lighted from below with diffused lights of known strength. The observer could not detect the slightest difference in the appearance of the fish even when one light was five or six times the strength

of the other. Yet, he says, fish are known to perceive differences in brightness which are as 1 : 1.23. Hence von Frisch's assumption that the color of a fish proves that it recognizes this color as identical with that of its background is unproven. Hess believes that color adaptation may be due to brightness or to the intensity values of light or it may not have a visual cause at all and he cites Dorflein's experiments with crabs which were kept in the dark and yet turned red. Crenilabri were also used by Hess. Part of the fish were put in a ruby glass aquarium with a background of white walls and the others in a black aquarium covered with a black cloth. After eight days it is said, no observer could see any difference in the fish. Fish were trained by him for yellow food but could not distinguish it against a blue ground or a gray of the same brightness. He thinks Washburn and Bentley could draw no conclusions from their work on the color vision of fish because of their method.

He insists that a protective device to be effective must take place in a few minutes and not in a few hours. The facts of color adaptation in the human retina are alleged as against the assumption.

In answer to the evidence of the *Hochzeitkleid* for vision he declares that fish which spawn at a depth of from six to eight meters cannot see red. Red can be seen directly at from three to four meters but viewed obliquely it is brownish or grayish. Markings, therefore, can be of little value in deep water and yet fishes which spawn at great depths have these markings. In all his work Hess clings to the belief that fish have the vision of color-blind men.

Von Frisch in reply to this last argument gives a long list of fish with the depths at which they spawn and the time of spawning, *i.e.*, night or day. He admits that many of the fish which spawn at night have brilliant colors. But, he says, when it is seen that most varieties take on color at spawning time, and at no other time, and that it is always characteristic of those which spawn in shallows, where conditions are favorable for the perception of brilliant color, it is only natural to believe that the wedding dress is an attractive cloak.

Birds. Bingham (4) investigated the perception of size and form in chickens, using the Yerkes-Watson apparatus, which is described in the Behavior Monograph (1911, vol. 1, no. 2).

With this apparatus the size, form, and relative position of the stimulating object as well as its brightness can be independently varied and controlled. The first experiments were concerned with size—the discrimination of circles of unequal size. The stimuli were at first complex, differing in form, size and brightness. Little by little they were changed until the only distinction was that of size. Under these circumstances the birds learned to discriminate between circles whose diameter differed from the standard six centimeters by one-fourth to one-sixth. The control tests left no doubt in the minds of the experimenter that this discrimination was made entirely on the basis of size. He also succeeded in teaching one bird to distinguish between a circle and a triangle of equal area. The bird was unable, however, to make this discrimination when the relative positions of the forms were changed and he thinks the power depended upon the unequal stimulation of different parts of the retina.

Hunter (28) in discussing this bit of experimentation, together with some other work, emphasizes the necessity of considering the background in all such investigations. The position is taken that the vision of animals is probably what may be called a pattern vision, that animals see a form within an outlined visual field which must also be varied for perfect control. Real form discrimination he thinks is a more abstract and later mode of perception.

The dual visual theory assumes that the cones of the retina function for daylight and the rods for twilight vision and that only the cones have the power of adaptation. A study of the eyes of nocturnal animals would seem valuable here. Such studies have been made before. Hess investigated the pupil-motor valence of the dark adapted eye, but did not make any comparisons under conditions of bright adaptation. Katz and Révész (30) do this in a study of the eyes of owls. They used the light from a Nernst lamp filtered through colored gelatine plates. There was a variable opening for the light which could be easily controlled. Owls which had been kept long in the dark were tested with a very weak light from a small opening. The strength of the pupil-motor reaction was as follows: YG, G, GB&B, R&O, BR. For the two investigators the order was: YG, GB, B, O, R, BR. The human eye makes a difference between GB and B and between O and R which the animals

do not, but the pupil-valence is the same for the two—green is the strongest color. For the bright adapted human eye the order was G, YB, O, R, BR, B, GB. In the change from brightness to darkness the colors O, R, and BR became darker than the GB and B (Purkinje's phenomenon). The results for the bright adapted eyes of the owls were exactly the same as for man, therefore owl's eyes do undergo adaptation in such conditions and also show the Purkinje phenomenon. Changes in strength of light, a series of 16, showed that in owls there was a real increase in pupil-motor excitability in dark adaptation, inasmuch as the absolute threshhold of the stimulus lay much lower. The human eye under such conditions showed a sensitivity not much greater than in the owl. The results of this investigation agree with those of Hess who showed that cones under daylight vision function similarly to the rods. The dark adaptation experiments showed that the difference between rod seeing and cone seeing is not so great as has previously been supposed.

Leplat (34), in a histological study of the eyes of birds, including nocturnal birds, confirms and corroborates the conclusions of Hess as to their power of accommodation.

AUDITION

Mammals. Part I of Johnson's monograph (29) is concerned with the discrimination of pitch in dogs. He gives a critical historical account of the Pawlow method and of the work of Goltz, Merk, Kalischer, Rothman and Swift. The purpose of Johnson's experiments was to try to confirm Kalischer's results under stricter control and to find a method of testing the power of pitch discrimination in higher vertebrates. In the preliminary experiments, two dogs seemed to have perfected a discrimination between two tones c(256dv) and g(384dv) when sounded on a tuning fork struck by hand, when sounded on the Stern variator, when sounded on forks and different variators indifferently and when included in chords. In response to the low tone, the dogs put their forefeet on a chair and waited to be fed; to the higher tone they were trained to mount a low box for the feeding. It was felt, however, that the control had not been sufficient, that the animals might have been reacting to unconscious cues on the part of the experimenter, who was

always in the room, or that they had learned the order of presentation which was not always recorded. For these reasons it was determined to repeat the work under conditions which would render such helps impossible. In the next experiment there was an attempt to train two dogs to react to the same stimulus tones; but in this case the forks were actuated in an adjoining room and the sound was conveyed by tubes to a point just over the animal's cage. The experimenter, in another room, released the cage door by means of a string. The dogs were to respond to the "c" fork by mounting a chair on the west side of the room and to the "e" fork by mounting one on the east side. In case of a proper choice, food was dropped in the chair from a chute above it. After 37 days when each dog had had 505 trials, there was little evidence of discrimination and the conclusion was forced that the first learning had probably been due to unconscious helps, to differences in the duration or intensity of the stimuli, or to some positive habits of the animals. In the next experiment these factors were most carefully watched. The details of the control are given in the monograph. There was a well planned bit of apparatus used which was so arranged that the animals were to go down an alley, and then turn to the right or the left in response to a signal which was not given until they reached the place of turning. It was hoped in this way to overcome the difficulties involved in a delayed reaction. But here again after 92 days the problem was not learned. The contention is faced that a pure tone is too difficult of localization and is too far removed from the tones to which the animal gives instinctive reaction to serve as a useful stimulus for learning. In some later experimentation the animals learned in a few days to localize sounds given by buzzers but the experimentation failed to show that the animals were at all sensitive to pitch differences.

Birds. Lashley (32), from some brief work with an Amazonian parrot, tells us that it imitated singing tones from violin, cello, piano and voice, and that 30 whistling tones were imitated. The register for the singing tones was one octave upward from c 256, for whistling tones two octaves upward from f 384. The response in case of the singing tones was a series of tones with many changes in pitch. The whistling tones were a series of half tones beginning with f 384 and they gave

a coefficient of correlation with the stimulus of $.658 \pm .059$—a correlation far too great to be due to chance alone.

OLFACTION AND CHEMICAL SENSE

Fish. Copeland (12) concludes after a study of the Puffer that while sight plays an important part in the finding of food the reactions to concealed food depend upon olfaction. The experiments with concealed packages of food and cheese cloth showed more visits to the one than to the other and that these reactions depended upon the olfactory organs since they ceased when the sense was rendered inoperative and were only resumed when it again became functional.

Shelford (50, 51) reports some work on the reaction of fish to evaporation and to atmospheric gases. He finds that "short exposure to high evaporation increases the sensibility to high evaporation" and that "in survival time experiments, heightened sensibility was sometimes followed by depression and apparent fatigue." The fish detected differences in the character of the water charged with gases as was shown by definite behavior. The exact mode of detection was not studied.

Parker (43) gives, in the paper here reported, some of the results of his study of *Ammocoetes* and *Amiurus* nebulosus. He is chiefly concerned with the relation of the general chemical sense to taste. He tested the whole body of his animals with different chemicals and gives the exact details of his findings. Like Sheldon he found no stimulating effects from sugar. He thinks sensitivity to sugar is probably a recent evolutionary acquisition and says that it cannot be due to osmotic pressure which is relatively high, but it is a real chemical effect on the nerve endings. There was a considerable diversity in the reactions to quinine and the salt was least efficient except in the mouth. Olfaction is a chemical sense, stimulated in this case by substances in solution. It acts as a distance receptor and is both structurally and functionally in strong contrast to taste. He agrees with Sheldon and Herrick that the chemical sense is the primitive sense from which olfaction and taste have differentiated and attempts to give some of the mechanism of the change.

Amphibians. Copeland (13) from his study of the spotted newt draws conclusions which differ somewhat from those

of Reese in 1912. He used the method Parker, Sheldon and others have used and as controls had animals in which the external nares were covered and others in which the olfactory nerves were severed. He thinks there is first a visual response to the object which is then tested as to its food properties by olfaction and that any snapping at an edible object depends upon olfactory stimulation by substances in solution.

Sound as a directing influence in the movement of fishes is the subject of a paper by G. H. Parker (42). The experimenter set up a tank 50 x 6 x 100 cm. made of wood 3.5 cm. thick, with a controllable inlet and outlet for water. The tank was screened and illuminated by reflected light from the ceiling, or from an incandescent light hung directly over it. The stimulus was an iron ball pendulum which struck the exact middle of one end of the tank with a momentum of 361200 C.G.S. units. The ball weighed 4300 gr. The contact produced a low booming noise. Fishes were put in five at a time and tested 50 times. The positions of the fishes in the tank were noted before and after each stimulation. Then the pendulum was shifted to the other end of the tank and the experiment was repeated. The first group of fish was followed by another group of five. *Tautoga*, *Stenotomus*, young kingfish and swellfish, he says, showed unmistakable tendencies to avoid the sound center. Sea robins tended to move toward this center. The killifishes ceased movement but neither moved toward or away from it. He asserts: "It is obvious that fishes are stimulated by sound but most sounds are generated in air and either fail to enter the water or enter it to so slight a degree that they are of little significance for fishes. The surface between the air and the water is an extremely difficult one for sound to penetrate in either direction so that most sounds generated in the water or in the air stay in the medium of their origin. Such sounds as reach fishes, however, not only influence their movements but also the direction of their movements." No doubt all who read Parker's paper will be willing to admit the possibility of the truth of this last statement but few, the reviewer fears, would be willing to admit that he has proved that sound did reach these fish or that their movements were caused by sound.

INSTINCT, HABITS, ETC.

Mammals. Little work with mammals is listed in this field for 1913. Haggerty (24, 25) has published two popular articles. The first deals with some of the methods and results of comparative psychology and the effects of such study upon the development of the science as a whole and the second gives an account of the behavior of apes.

There should be more observational notes on the early development and behavior of animals. Lashley and Watson (33) offer such an account of a young monkey born in the laboratory of Johns Hopkins University. These notes cover a period of 15 weeks. On the sensory side there was noticed what seemed to be slight unadaptive responses to sounds on the second day, some degree of localization was seen by the second week and there was some evidence to show that food was recognized by sight on the fourth week. On the third day the head and eyes followed a moving object and two days later the grasping reflex was seen in connection with an object. The report covers the physical and sensory-motor development, the behavior of the adults toward the young, the play activities and the mode of learning. There was no evidence to show that the young monkey ever gained control over a new activity through imitation.

Franz (16) has an interesting note on the preferential use of the right and left hands by monkeys. The animals used were ones which were being trained previous to certain operations on the occipital lobes. (See Mental Processes of Rhesus Monkeys, *Psy. Rev. Mon.*, Sup. No. 52, 1910.) In the course of this work, some observations were recorded of a series of tests made to discover whether there was any preferential use of either hand. Food, sweet and bitter, was presented on glass plates so that the one was on the right of the animal, the other on the left. The arrangement was carefully changed so that half of the time the sweet was on the right of the animal and half of the time it was on the left. He thinks that more observations are needed before anything definite can be said although the results indicated that of six monkeys one showed a decided preference for the use of the right hand and two preferred the left hand.

Is savageness and wildness inheritable ? This question formed the basis of some experimentation made by Yerkes (59) with rats. The original animals consisted of wild male rats captured in

and about Cambridge. The tame rats were taken from a strain bred for ten years past in the Harvard Zoological Laboratory. There were two types of this strain, one of which was known to have more wild blood than the other. These rats were graded from 0 to 5 in savageness, wildness and timidity. The indications of savageness were biting, exposing or gnashing teeth, jumping at hand or forceps and squeaking. The signs of wildness were attempts to hide, excited running, squeaking, urination, defecation. Timidity was indicated by attempts to avoid experimenter, chattering or gnashing of teeth, cowering, urination and defecation. Wild males were crossed with tame females and the offspring, 78 in number, bred by others, were then tested three to five times by the experimenter who did not know the genetic relations of the rat and therefore was entirely unprejudiced. The results showed (a) diminishing savageness, wildness and timidity; (b) sex differences; (c) marked differences from the original stock. Another cross, where the tame female strain had back of it wild blood, showed this wild blood in the first generation. The author thinks the tests prove conclusively that savageness, wildness and timidity are heritable behavior complexes.

Birds. Shepard and Breed (52) compare the relative significance of maturation and use in the development of the pecking instinct of birds. The chicks were incubated absolutely in the dark, taken from the incubator to the dark room at night, fed by hand in the dark for several days, and finally were taken out for experimental observation on the fourth and fifth days. The number of complete pecking reactions in 50 was taken as a standard of accuracy. When brought into the room the chicks were temporarily phototropic. As compared with the normal groups pecking from birth, the points noted were (a) the uniformly poor initial records and (b) the rapidity with which normal accuracy was attained. At the beginning the efficiency of the chicks was 18 per cent below normal but in two day's practice, in which there was no excessive practice due to delay, the birds reached the normal standard. Hence, the experimenters believe, it may be assumed that the curve after the first two days is mainly a curve of maturation.

We have in the article by Craig (14) a continuation of the work reported in 1911 on the stimulation of ovulation in birds, etc. There are 24 new cases given with all of the essential details,

where egg laying was brought about by stimulation of other females, by stroking with the hand, by animals in distant cages. He says: " In so far as ovulation is dependent on environment it is dependent, not upon any one afferent stimulus, but upon the entire situation—involving the female's inborn disposition, her whole past history and all the factors in the present environment which affect the social and emotional situation."

On the observational side Sherman (53) gives a careful study of the sparrow hawk. She discusses the nest life and the instinctive activities concerned from the time of choosing the nest to the flight of the fledglings. Bergtold (5) as a result of observations covering six years writes of the distribution, song, food, mating, nests and nestlings of the house finch.

Barrows (4a) relates a curious story of the concealing actions of a bittern. The bittern assumes a characteristic attitude on alighting. Its head, neck and legs are all in the same line and its bill points to the sky. After holding this position for a few minutes it relaxes, draws down its head and seeks for food. Mr. Barrows had the interesting experience of seeing a bittern in this rigid attitude. But the bird, when the cattail flags in which it stood were swayed by a passing breeze, set up a similar motion. The movement involved the whole body even the legs. The observation was repeated and was confirmed by another man.

There are a few articles on bird migration. Phillips (44) treats the subject from the standpoint of its periodic accuracy. He gives facts and figures for a number of birds. For instance, there are records of the return of the bobolink to Concord, Mass., which cover a period of ten years. For this time the average date is May 6 and the greatest deviation from this date only six days. The journey which these birds take, he says, is 2000 miles in length and occupies two months, yet the average error is only 9 per cent. The time of the return of the chimney swifts has been kept in New Market, Va., for twenty-three years. The average error is only 2.2 per cent. The author discusses in a brief way the prevalent theories of migration: (a) the biological theory of distribution; (b) the theory which makes migration a continuous movement and not a single flight due to a migratory impulse; (c) the theory which makes the breeding of tropical birds furnish the impulse for the northern migration

of others or which makes it due to the pressure of numbers because of breeding and the consequent lack of food in the dry season; and (d) the sexual hormone theory. The article closes with the following sentence.: "The writer is familiar only in a general way with the subject in hand and has merely attempted to call attention to an aspect of migration which does not appear to have been much discussed."

Cooke (11) deals with the same subject, discussing the relation of weather to migration. From a series of records, extending in some instances over nine years, he makes a comparison of the times of the arrival of certain birds with the weather records of the same seasons. He is interested not only in the time of the arrival but also in the probable effect of the weather on the entire time of the migration. He tries to find out also whether or not the weather of an entire season influences the periodic flight, *i.e.*, whether a long, cold winter or a prolonged hot summer, either in the locality from which the birds come or to which they go, affects the time of migration. He concludes that the variations in the time of arrival from year to year do not agree with the variations of the season, and that during the spring migration the direction of the wind seems to have little or no effect upon the arrival of the birds.

A study of animal hypnosis is found in Mangold's (39) paper. For his own experiments hens have served chiefly. He gives Verworn's explanation of the phenomenon and cites much experimentation with many animals. He attempts to connect it biologically with that spontaneous immobility often seen in animals, *e.g.*, in the hen before the treading of the cock.

LEARNING

Szymanski (54) in a very carefully controlled series of experiments tried to prove whether sound can serve as a stimulus for movements in a definite direction with cats and dogs. He assumed that Kalischer, Swift, Zeliony and others were right in their assertion that dogs and cats can discriminate tones exactly. The experiments were conducted in a dark chamber in a cellar of the institute. The space used was 9 x 2.7 m. in size and was lighted by an electric light hung from the ceiling directly over the place of experimentation. The floor was covered with linoleum and was washed every day with soap and water. For

animals he used three fox terriers and two cats. The arrangement of the food boxes, the mode of release of the animals from the cage, the method of giving the stimulus, are all carefully described in the paper. He endeavored to direct the animals to their food by means of sound. They failed within the limits of the experiment to form the association but did develop definite individual habits of response. In the second part of the research he changed to olfaction as a stimulus with the same animals. The experiment was so arranged as to make use of the habits which the animals had set up in the previous work and to strengthen them. Then the mode of procedure was so altered as to compel a modification or change of these habits. He says in discussing this part of the work that if an animal is put in a position where the stimulus is of no particular interest it reacts to this stimulus not directly but with an ordered series of movements. He concludes that his animals were of two types—some more predominantly visual, others kinaesthetic-motor. His experiments were ingenious, his curves and tables are interesting and his discussion is illuminating.

Sackett's work (48) with porcupines, at the Clark University experiment station, was carried on in the summer out of doors, and in the winter in a large unheated room connected with dark dens and an outside runway. There was a strong effort in all of the work to approximate the natural conditions of the animals as far as possible. There were 16 animals in all used in the experimentation.

The paper begins with an interesting account of the natural life of the animal in all phases of its activities.

The first problem undertaken was one connected with right and left-handedness. The results show that porcupines have very little tendency to be either right or left-handed, but that they can be trained in a few days to take food with a given hand. The theories which try to account for right-handedness are discussed at length.

The next task set the animals was to take carrots with one hand and cabbage with the other. After a training covering 5,000 tests, no. 3 reached for cabbage with his right hand no matter when, where, or by whom it was offered. In an interval of 100 days there was little loss of ability. Other animals were used and developed equal skill.

It was not determined upon what sensory basis the above response was made. It may have been olfaction or vision. In some experiments where sweet potato was used instead of cabbage the experimenter thinks that form, size and color were eliminated which leaves brightness as a possible cue. The human element was always present and although the writer concludes " that the animal's basis for reaction was something else than the unconscious idiosyncracies of the experimenter," the reader cannot feel so sure that this was true.

The results from the puzzle box experiments did not differ in any significant way from those obtained by others with different animals.

The third attempt was to teach the animals to discriminate forms. These forms were cut out of wood, and the opening which was to be discriminated was the entrance to the food box. The author says that they learned to discriminate the circle from the other forms when presented in pairs and eventually when given with six others. There was a strong effort to control this part of the work but the basis upon which the choice was made was again left unsettled. The experimenter was always present in these tests.

Color tests, which formed the fourth part of the work, were made by the use of food boxes covered with standard colored papers. They gave negative results.

The brightness tests which followed were more successful. It appeared that the porcupine was able to discriminate a brightness difference of about ten shades of the Nendel series of grays. Observation of the behavior of the animals led to the belief that one animal reacted always by choosing the black while the other reacted by avoiding the white.

In the maze tests the porcupine compared most favorably with other animals. Rotating the maze caused confusion, but they were able to follow the path in the dark when they had learned it in the light and learning in the dark differed little from that in the daylight.

The author says: " Memory tests of the porcupine show better retention where motor or kinaesthetic factors are characteristic of the responses than where the same general motor response follows a choice of sensory stimuli, *i.e.*, ability to thread

a maze and operate a puzzle box is retained better than ability to choose between the forms and the brightness boxes."

This paper is suggestive along many lines. The attempt to approach in the experimental field the conditions of nature is one too frequently neglected. One could wish, however, that instead of covering so great a field some of the tests, especially those on the sensory side, could have been carried farther and under stricter control.

McIntyre (35), in a paper before the British Society for the Advancement of Science treated the rôle of memory in animal behavior. The chief questions considered were: the existence of mental images or free ideas in animals, their origin, their biological significance and the tests that indicate their presence.

On the other side of the water the trained horses of Elberfeld have occupied the focal point of attention in the field of animal learning. Nothing seems too abstract, too great or too difficult to attribute to them. The readers of this journal are familiar with the work of Kluge Hans. It is known how his master, von Osten, sincerely believed that the horse could read, spell, etc., how the learned men who visited him were puzzled, and how, finally, under controlled experimentation, it was proved that the horse failed in all questions where the answer was unknown to those present and also when it was impossible for him to see.

Herr von Osten was broken hearted over the outcome but continued his training with the aid of a friend, Herr Krall, who had always remained convinced of the almost human intelligence of the animal. To this friend Herr von Osten left the horse at his death. Krall not only continued Hans's " education " but has also acquired six horses of his own all of which are in training. Some of these far exceed Hans in their attainments.

Krall is a man of intelligence and enthusiasm. He is said to be a good man incapable of dishonesty and for years he has made his home a laboratory for these animals. He is interested in psychology and possesses a considerable psychological library.

Many of the greatest savants in Europe have flocked to see these horses and have made their reports to various societies and in many articles. The account given here is a summary of the facts and no attempt will be made to separate, in the review,

the different articles which are listed in the bibliography. The readers are referred especially to Krall's own book and to the articles of Claparède, Buttel-Reepen, and Menegaux for other details.

Krall, after acquiring the horses, tested their visual acuity and range of vision, their perception of color, form, odor, taste, touch, two-point sensitivity, etc., and in each of these graded the horses excellent. The details of this testing are not clear but at least it was attempted. He has tried to give them, and he thinks that they have, ideas of beauty, time, direction, magnetism, etc. He has made an effort to teach them an articulate language. They are said to be able to extract roots to the seventh power, solve problems in algebra, read by taps of the foot, spell phonetically, recognize and name objects and answer questions.

Herr Krall stands before a blackboard and asks the questions orally or writes them on the board, or indicates the letters or figures desired, and the horse upon a special board paws the answer. The groom is usually in the box stall which opens into the room and although the spectators cannot see him it is often possible that the horse can. No one seems to have any suspicion of Herr Krall, but the groom, Albert, is frequently mentioned with doubt.

The vision of some of these horses has been so effectually shut off that there appears to be a general belief that this sensory control has been in some test cases excluded. There is also a blind horse, Barto. If sensory cues are being given here they have failed of discovery since Krall refuses to submit to a commission.

The most remarkable work of the horses is arithmetical. Muhammed solves problems like the following:

$\sqrt[4]{4477456}$ Ans. f., r., 46, repeated, f., f., r. 46.

$\sqrt[2]{4096}$ Ans. f. 36, f. 74, f. 46, f. 46, r. 64.

$$\frac{(3 \times 4) + 36}{3} = ?$$

The following is one of the arrangements which Krall has for use:

7	1	5	4	6
DB	G	R	B	BB

Here are some directions for the use of the diagram:—

Multiply the two right hand numbers. r. 24. Add them. r. 10.

Multiply DB and BB. r. 42. Multiply DB and R. f. 42, f. 34, r. 35.

He sometimes writes the directions on the board as: "Adire vängt troa + dus." Ans. f., f., r. 35.

Phonetic spelling, which Krall says was acquired spontaneously, is strongly urged as a proof of intelligence. That this varies as between horses is also argued as speaking against training. For instance the spelling of the word horse varies in Muhammed and Zariff and each at different times have spelled it as follows:—

Muhammed—bfert, bfrt, färd, färt, fert, frt, faärt, faerd. faert, färb, fpferd, frrt, pärd, pfärt, ppverd, pfer, pferd, tfert, fed, etc.

Zariff—bferd, färed, fferwt, fvert, pfrde, sdfert, pfert, bffet, fdaerp.

In the discussion of Claparède's articles before the French society of Philosophy the arguments as to the intelligence of these horses were clearly stated. Claparède was asked if he thought the fact that the horses had different alphabets was a proof of originality—a proof against the training hypothesis. He was asked whether the obscurity in which the tests were frequently made would not favor signs of some kind provided there was any trickery. Some one else wanted to know how he accounted for the tapping which frequently went on indefinitely. Does the horse ever rectify a mistake was one question. Claparède, to this, replied that he had never seen a mistake rectified by a horse unless there were signs on the part of some one

present although Krall said they sometimes did correct their answers voluntarily. Why will not Krall submit to a committee asked one ? Claparède answered " Krall will not put his horses at the entire disposition of a commission because a commission by its nature would alter the character of the responses, introduce new factors, and suppress under the pretense of control the very elements essential for the response." Buttel-Reepen had said that he never saw any spontaneous work of any kind. Claparède was asked here if he ever saw any. He said perhaps the changing from one foot to the other which the animals did in counting units and tens was spontaneous.

The society discussed the mathematical features at some length. It was emphasized that it was impossible for an animal to get at the results in the time which it took them by any of the ordinary operations of arithmetic. They exceeded in ability the finest mathematicians. Krall never would show any of the steps of the work. A man would take years to acquire this ability. How was the horse trained. Mathematicians say that a brain that can extract the fifth root of 147,008,443, should know that even numbers have even roots and that the fourth power of 10,000 cannot be 2. There seems to be a general feeling that the errors do not increase with the difficulty of the problem. M. Plate, however, who took a stenographer with him on his visit says that in his records they did so increase. Claparède's request for simple problems was refused. Some thought that this was because mistakes in very difficult problems would be excused while errors in a simple problem would not be. But the general feeling was that if Herr Krall insisted that this was an intelligent process comparable with that of men he should show its mechanism.

A German protest against the assumptions of Krall was made at the International Congress of Zoology at Monaco. It was signed by Bethe, Bühler, Dorflein, Ettlinger, Forel, Freund, Lippman, Semon, Wundt, Tschermak, Wasmann, and others. They say that the doctrines of Krall and his adherents contradict the conceptions of evolution and are irreconcilable with the facts established by scientific physiology of the senses and by experimental and animal psychology: that such movements will serve to discredit any careful work in animal psychology; that the facts are considered by the undersigned as not proven and

improbable; that the conditions do not answer to those of modern psychology, zoology or the methods of the psychology of the senses; and that a profitable discussion is not possible unless the experimental work can be scientifically controlled.

Claparède tries to refute these statements and says that the method of protestation is not a scientific method. He insists that he witnessed tests where correct responses were given under conditions which absolutely excluded the possibility of guidance by voluntary or involuntary signals. But Claparède did not succeed in getting correct answers under conditions where the answer was unknown to those present and Edinger affirms that in his presence any attempt in which the solution was unknown to the attendant did not succeed.

What has been said of the horses applied equally well to the Mannheim dog of which Mackenzie writes and to the horse reported by O'Shea.

The presence or absence of ideas in animals always furnishes a fruitful field for discussion. In the beginning of his monograph on the delayed reaction, Hunter (28a) examines the different lines of evidence offered to prove the presence of such ideas. He then defends the thesis, by means of arguments backed by his experimental investigation, that no ideas need be postulated in a sensory-motor act where the stimulus is present at the moment of the response and that when the brief stimulus and response are separated by an interval the "carrying over" may be by other means than ideas.

Rats, dogs, raccoons and children were trained to go in a definite, though variable, direction, which was indicated by a light previously exposed at the place. The time between the exposure of the light and the release of the subject was then increased as far as possible without destroying the habit. It was found that the maximum delay consistent with a successful response in rats was only 10 sec., in dogs 5 min., in raccoons 25 sec. and in children 25 min. The delay of a child of two and one-half years, however, was less than 1 min. The great significance of the work was not so much in the length of this interval as in the behavior during the interval. The rats were enabled to overcome the delay by preserving a definite orienting attitude of the whole body and the dogs by overt orientation of the head. The raccoons and children maintained no such

attitudes. In their cases the author, to account for the successful reactions, assumes that some intra-organic non-orienting representative factor must exist. Thus the reaction cue for all the reagents except the older children is thought to be sensory rather than imaginal and the non-orienting sensory factors are believed to have a memory function which is designated here as sensory thought. This type of mental control, the author reasons, is probably earlier than imaginal thought. The monograph is a valuable one for which a brief review is inadequate.

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PYCRAFT ON THE INFANCY AND COURTSHIP OF ANIMALS[1]

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In the two volumes here under consideration, Pycraft has presented a large compilation of data bearing upon the two subjects involved. The emphasis throughout is upon the evidences of evolution. The point of view is that of the naturalist and zoologist rather than that of the experimental behaviorist.

The chapter headings lean to the fanciful. The topics covered in the treatise on infancy may be given, however, as follows: Mammals, their coloration, their early activities and the mile-stones of evolution which they present. This is followed by three similar chapters on birds, and these by three more considering the same topics in reptiles. A chapter to each of the following topics completes the book: Tadpoles, the infancy of fishes, the infancy of crabs and caterpillars, and puzzles and paradoxes. The dominant note of this volume is that infancy contains the key to the solution of many important problems of evolution. This is especially emphasized with relation to coloration in the successive change from stripes to spots and then to uniform color. The skeleton, as usual, is made to bear its share of the proof of evolution.

From the standpoint of the readers of this journal, the following points alone need to be made: (1) There is an ever present tendency toward the uncritical acceptance of field observations. On page 25, *e.g.*, we read: "But the finishing touches of this education [play] do certainly seem to be imparted by direct instruction from the parents. Cats certainly train their young in the art of mouse-killing, etc." This, of course, is not borne out by the careful work of Yerkes and Bloomfield.

[1] Pycraft, W. P. The Infancy of Animals. Henry Holt & Co., New York, 1913, P. 272.

———— The Courtship of Animals. Henry Holt & Co., New York, 1914, P. 318.

A similar experimental analysis of other cases of instruction and imitation would probably lead to similar results. (2) In discussing the relation of protective coloration to habitat, the author presents the view that the liveries have been evolved to fit the instincts which keep the animals within their peculiar environments. The familiar contrast between the tiger and the lion is a case in point. Inasmuch as the young lion shows traces of a spotted livery, it is to be inferred that at one time the lion wore a striped coat. The evolution to a stage of self-color has followed a change of habitat. Certainly the reverse should be considered, *viz.*, that the instincts may have been forced into alignment with the changes in coloration by the powers of natural selection. (3) The present volume contains a very valuable collection of observations upon instincts. The experimental behaviorists may well take these into account in governing the conditions of their experimentation not only upon instinct itself, but upon discrimination and the "higher" types of behavior.

The volume on the Courtship of Animals draws data from the life-histories of man, the apes, other mammals, birds, reptiles, amphibia, the fishes and insects. The large array of facts defy either summary or review. It must suffice to state the central theoretical problem of the book, the relation of structure and behavior to the theory of sexual selection. The Darwinian theory, in a modified form, is upheld. The brilliant colors and other secondary sexual characters are not to be viewed as the result of sexual selection but as the result of the stimulating activities of "hormones" or juices from the thyroid, pituitary, suprarenal and primary sexual glands. True behavior insight is manifested in regarding the mere activities of posture and display, rather than the type and degree of coloration, as the essential excitant for the female, inasmuch as many somber hued individuals perform the same preliminary antics. The displays and postures also are not to be regarded as the result of sexual selection but are to be viewed as the result of the hormones. The antics of courtship serve to arouse sexual excitement to the proper pitch in the female who then abandons herself to the more exciting performer. All force must be laid upon the more intense "mate-hunger" of the male and his desire for the gratification of the impulse.

A comment above made may be repeated here. For the experimental behaviorist, the observations here recorded offer innumerable suggestions toward the careful analysis of instinct. However the behavior data of courtship, as of any other activity, cannot be adequately handled until the facts of sensory discrimination are gathered. Until that time, however, such discussions as the present are both interesting and stimulating.

H. VOLKELT'S "ÜBER DIE VORSTELLUNGEN DER TIERE" [1]

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The present monograph is the second of a series of Arbeiten zur Entwicklungspsychologie initiated recently under the editorship of Professor Felix Krueger. The general purpose of the series includes all studies upon the genetic aspects of conscious activities. Hence, although the present work is primarily concerned with animals, it is not surprising that the author should hold that additional light is shed upon the nature of the consciousness of primitive man.

Volkelt's general problem is this: What is the nature of the cognitive (sensational, perceptual and imaginal) consciousness of animals? How do the objects of an animal's environment appear to its consciousness? The solution of these questions is sought by the study of contradictory types of behavior, behavior which at one moment is highly adaptive and the next moment quite as highly non-adaptive. That which arouses such opposed reactions must never-the-less still possess the same "value" or "interest" for the animal. The following are some of the cases of such behavior that are cited: (1) A spider which will normally rush out of its hole into the web in order to secure prey that has been trapped will retreat from this same prey if this is made to move continually towards the spider. In each case the same object (a fly) and the same interest (hunger) is present. (2) A pheasant which was accustomed to eat larva out of Lloyd Morgan's hand shrank back and gave the alarm note when these larva formed a large mass by clinging to each other. (3) If one rotates a bee-hive slightly, returning bees will seek the entrance at its old position although the entrance can undoubtedly be seen a few inches away. Again the same object

[1] Volkelt, Hans. Ueber die Vorstellungen der Tiere. Arbeiten zur Entwicklungspsychologie. Bd. 1, Heft 2., 1914, S. 126.

and the same interest is present, although at one time (when the hive is undisturbed) the bees' reactions are highly adaptive, while under the other conditions the behavior is non-adaptive. As Volkelt says, any number of these cases might be cited. The cases of adaptation are those vitally significant for the animal. The other situations rarely occur in the animal's habitat and are vitally insignificant.

The author now turns to the psychological interpretation of these types of behavior. The " übliche Ansicht," he says, is that animal consciousness is composed of structurally discrete states which now appear, now disappear,—always remaining relatively constant. This is the theory of the " dinghaften Konstantenhaltigkeit " of primitive consciousness. Such a view cannot account for the behavior cases above cited. As opposed to such hypothesis, Volkelt urges that the animal consciousness cannot be regarded as a sum of qualities to which the attributes of clearness and distinctness may be applied. The. animal's environment appears in its consciousness as a complex quality. This is the subjective correlate of the " whole situation " which in every case determines the animal's reactions, as opposed to a determination by discrete aspects of that situation. Volkelt here finds himself in harmony with Thorndike. The notion of complex quality is elaborated in the light of Krueger's studies upon tone. In a klang, *e.g.*, fundamental and overtones fuse into a unity. A change in any aspect of the complex quality will result in a change of the whole without, however, the changed aspect appearing as a discrete element in the whole. So in animal consciousness one finds leading moments which are the determining aspects of the complex quality. Each change in the sensory data results in a change of the quality. Whether or not this in its turn shall lead to an adaptive reaction will depend upon the co-ordinations which exist between the complex quality and motor responses. Adaptive reactions are those made to the vitally significant total situations.

Images are not present in animal consciousness in the sense of discrete elements. Past experience, when revived, is assimilated to present experience as a total complex quality.

Development from this primitive condition of consciousness through the stage of primitive man to the stage of the most elaborate consciousness proceeds by a breaking up, a differen-

tiation of the complex qualities into lesser complex qualities. The development of the pecking instinct in the chick foreshadows the larger development. At first the chick will peck at any thing of the proper size. As it grows older, it learns by experience to peck at certain objects only.

A number of telling criticisms can be directed against Volkelt's position as outlined above: (1) His central problem is the *ignis fatuus* of comparative psychology, *viz.*, knowledge of the structure of animal consciousness. The student can only designate certain functions which experimental evidence indicates are present in behavior. It is not even possible to speak definitely of conscious functions; for in any particular case, the processes in question may be neurological only, *i.e.*, sub-liminal to any consciousness that is present. It is for this reason that the term sensory, *e.g.*, is preferable to the term sensation. (2) This difficulty is well illustrated where the author says that the leading moments or aspects of the complex quality determine behavior without themselves being explicit. It is useless to ask whether animal consciousness is unitary or compounded and whether its aspects are clear and distinct. All that one can say is that certain factors in the environment condition a reaction. It is impossible to say whether these are sub-liminal to consciousness, whether they do fuse with and into a complex quality, or whether they form states which are just as discrete as occur in human consciousness. Either hypothesis can account for the facts because from the nature of the case we may never know conditions which will exclude the truth of either. (3) Volkelt makes much use of the notion that an animal's responses are made to the "whole situation." Thorndike is quoted in support. Now it should be pointed out that while this was a justifiable hypothesis at one time, what we need now are experimental analyses of the "whole situation" in order to determine just what are the stimuli to which the animal responds. As a matter of fact, such work has been and is going on in connection with discrimination tests. The results are not accessible at this writing, but they will undoubtedly do much to put our theories of the stimuli determining animal reactions upon a factual basis. It does not follow because animals, through their reactions, probably break up their world into different types of things than ours that therefore their reactions are conditioned

by total situations. The problem is one for experimental, not theoretical, solution.

In additon to the above general criticisms, the following detailed ones may be offered: (1) The bees whose homing was hindered by a rotation of the hive were evidently guided largely by kinaesthetic sensory impulses co-ordinated with the old position of the hive. The other cases drawn from the behavior of birds and spiders indicate merely that the differential cues for food are not the same for those animals that they are for the human observer. Because of this the fly, *e.g.*, is no longer "food" for the spider, but is now an "enemy." Wherever conditions change so that habits and instincts can no longer solve the problem, nonadaptive behavior always presents itself. (One could of course argue very strongly that the behavior of the spider in question was adaptive.) (2) I believe there are few American psychologists who would plead guilty to a championship of "dinghaften Konstantenhaltigkeit" as formulated by Volkelt. All we assume is that upon the second presentation of the same stimulus under the same conditions as at first, the same response will occur. The "übliche Ansicht" which Volkelt criticises has much in common with the abstract conception of an idea which critics seem agreed lay at the basis of Thorndike's address on Ideo-motor Activity at the American Psychological Association in 1912. (3) Volkelt makes individual development a process of particularizing an original complex quality, *e.g.*, the growth of the pecking instinct. He should not forget that there are also instincts whose stimuli are at first very limited. The development here is an increase rather than a decrease in the number of stimuli which will arouse the reaction.